Croissance et propriétés magnétiques de réseaux planaires auto-organisés de nanofils de Fer

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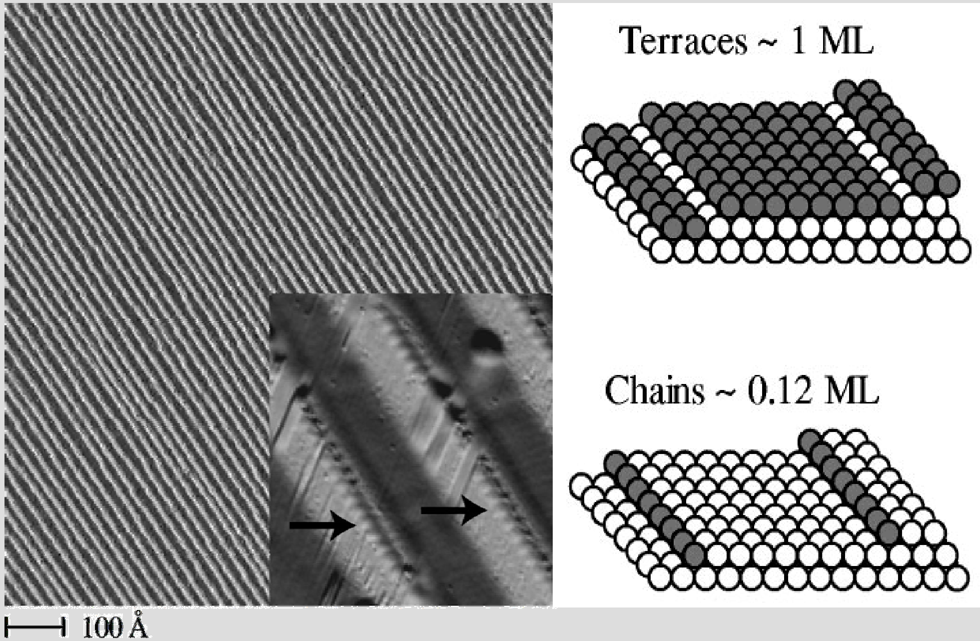
Grenoble

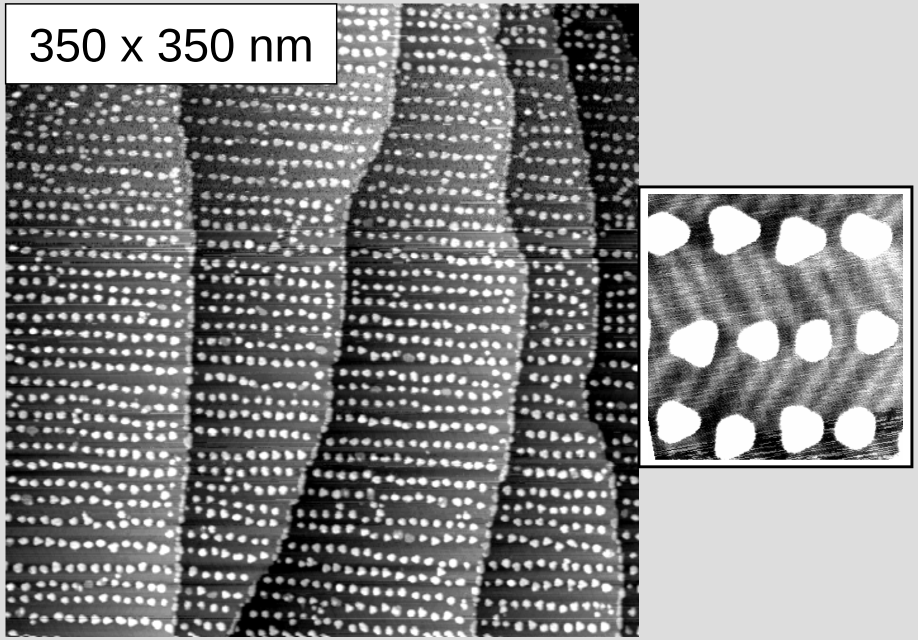
Self-organization at surfaces : 2D regular arrays of similar nanostructures

Stripes and wires Co/Pt(997)



A. Dallmeyer et al., PRB 61(8), R5153 (2000)
P. Gambardella et al., Nature 416, 301 (2002)
P. Gambardella et al., Science 300, 1130 (2003)

Dots Co/Au(111)



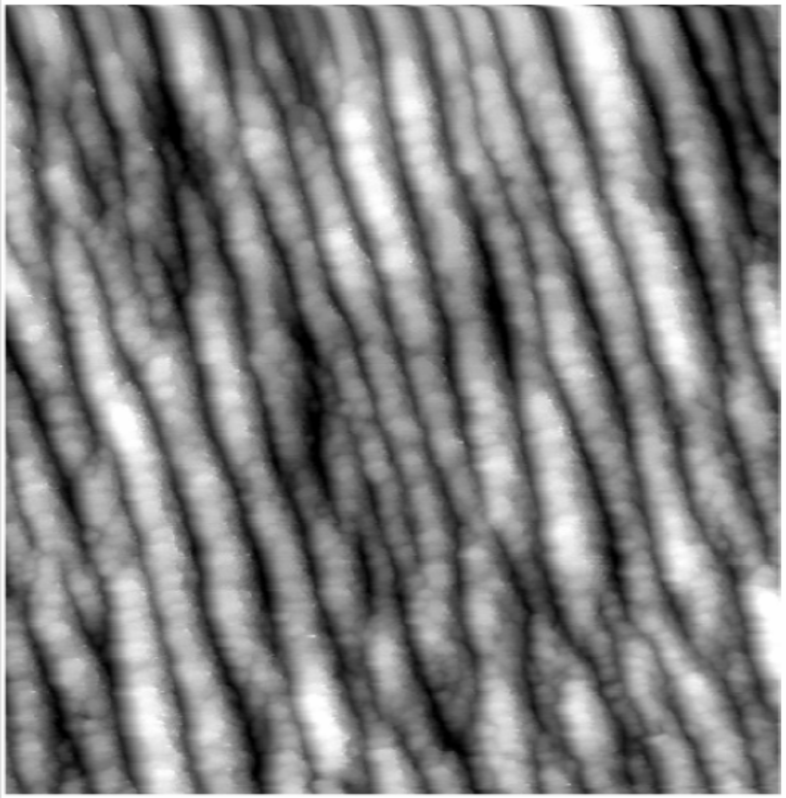
D.D. Chambliss et al., PRL 66, 1721 (1991)
B.Voigtlander et al., PRB 44, 10354 (1991)
J. P. Bucher et coll.; S. Rousset et coll.;
O. Fruchart et coll.

What for?

- Cheaper and beyond lithography
- Fundamental research: weak distributions > reliable analysis
- Applications? lack of versatility (tunability; use no vicinal nor reconstructed surface)

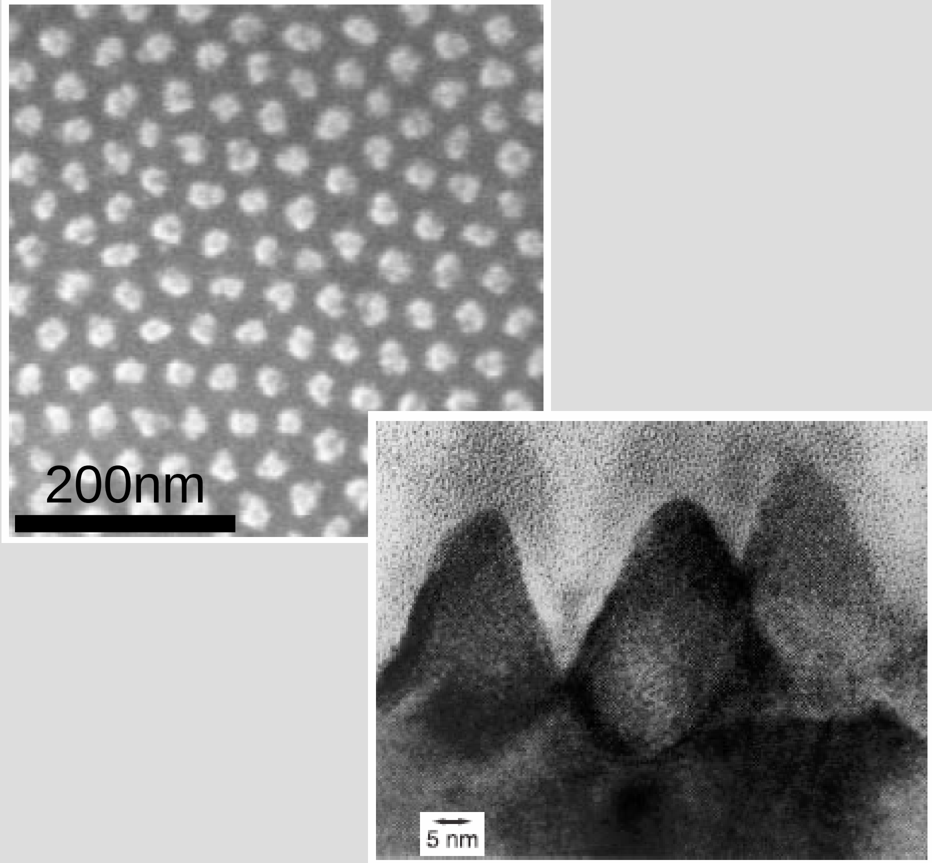
Demonstrated path: ion etching

Stripes and wires Ag



T. Aste and U. Valbusa, New J. Phys. 7, 122 (2005)

Dots GaSb(001)



F. Facsko et al., Science 285, 1551 (1999)

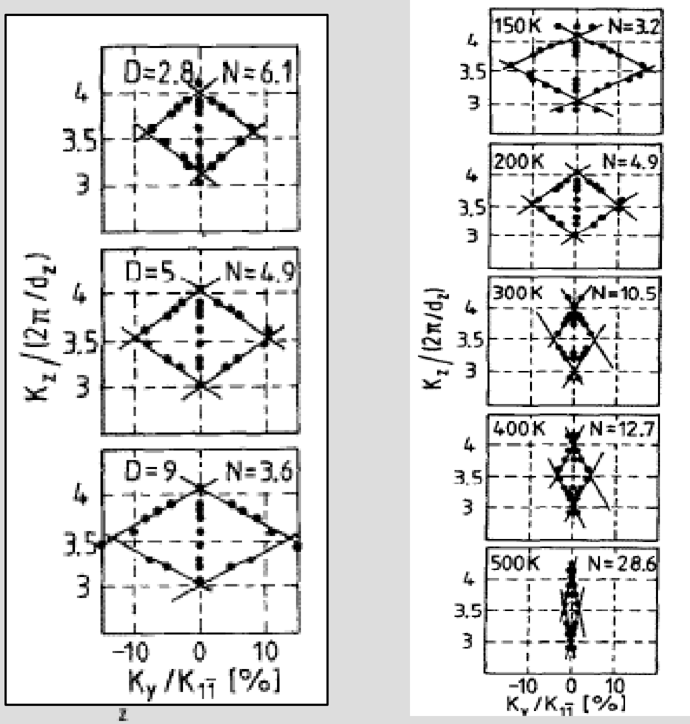
Magnetic wires

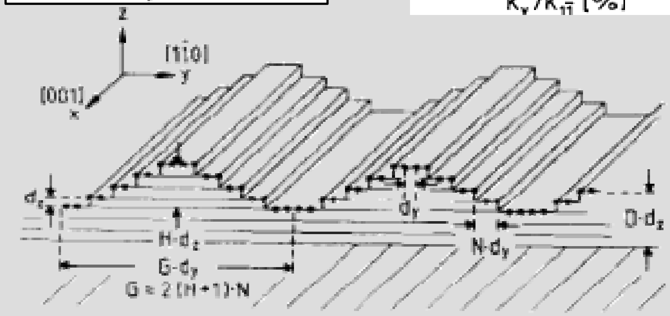
➩ Etched magnetic films (with or without mask)

Hills and grooves by kinetically-limited growth on bcc(110)

Fe(110) homoepitaxy

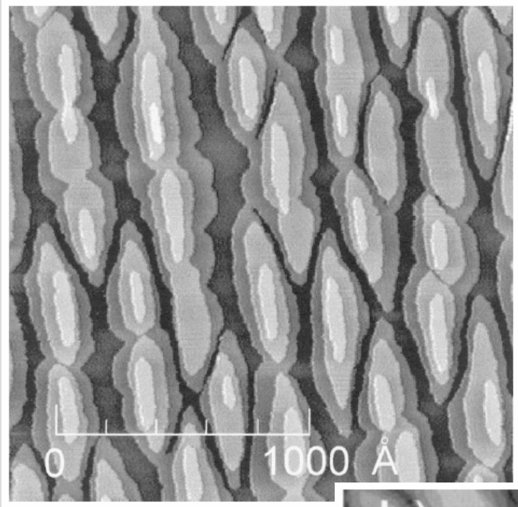
LEED





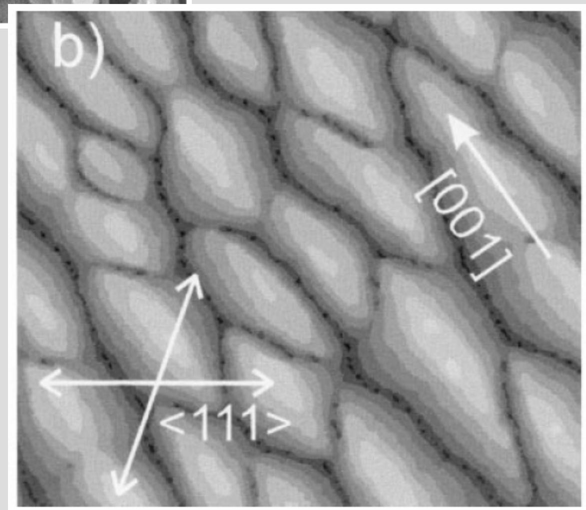
M. Albrecht et al., Surf. Sci. 294, 1 (1993)

W(110) homoepitaxy



STM

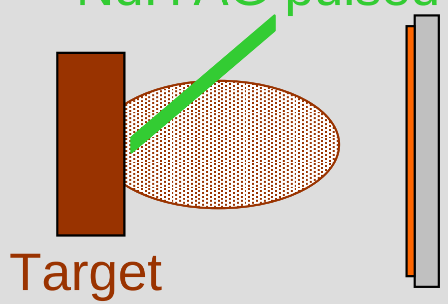
Simulation



U. Köhler et al., Surf. Sci. 454-456, 676 (2000)

Any use for magnetic wires?

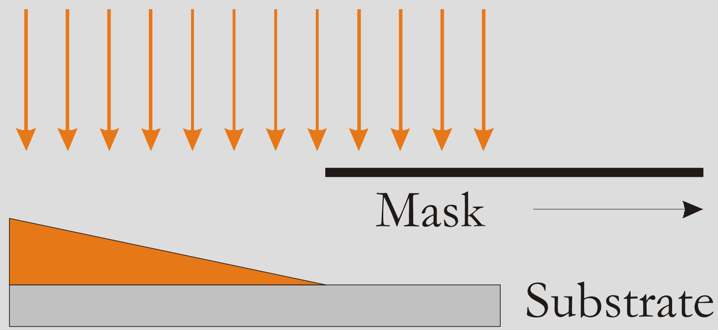
Pulsed Laser Deposition (DLP) in UHV



Analysis

- RHEED (Reflection High-Energy Electron Diffraction)
- STM (Scanning Tunneling Microscopy)
- AES (Auger Electron Spectroscopy)

Wedges

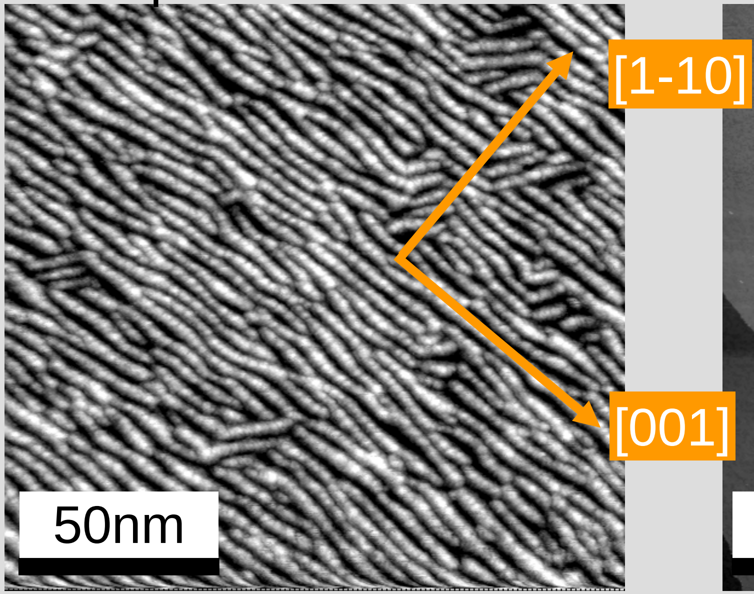


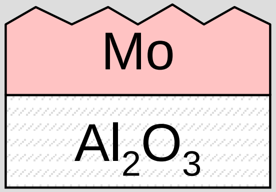
Buffer layers for trenches

Mo

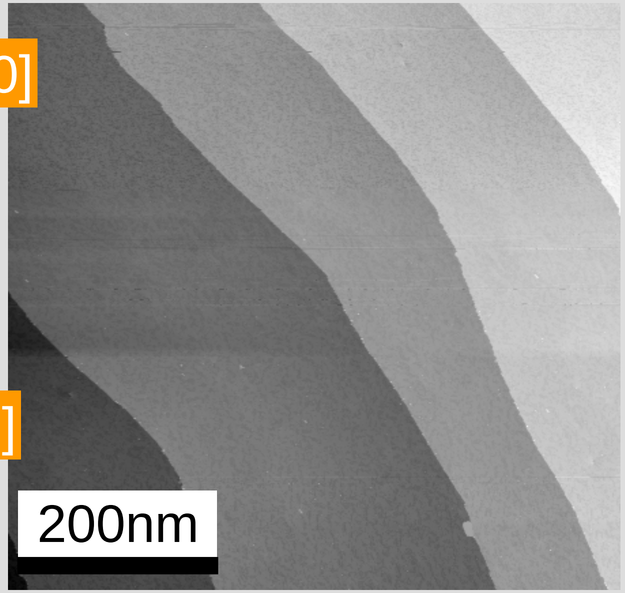
Deposition of bcc refractory metals along (110)

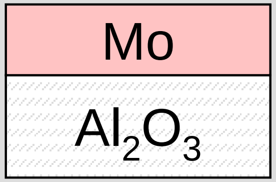
RT deposition



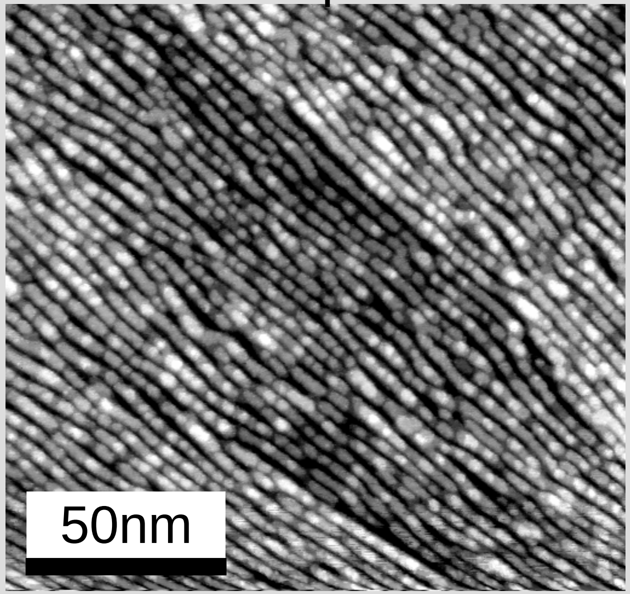


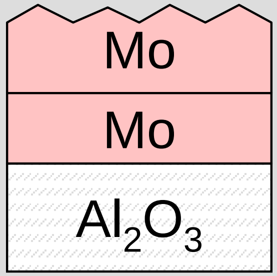
Annealed 800°C





RT-150°C deposition



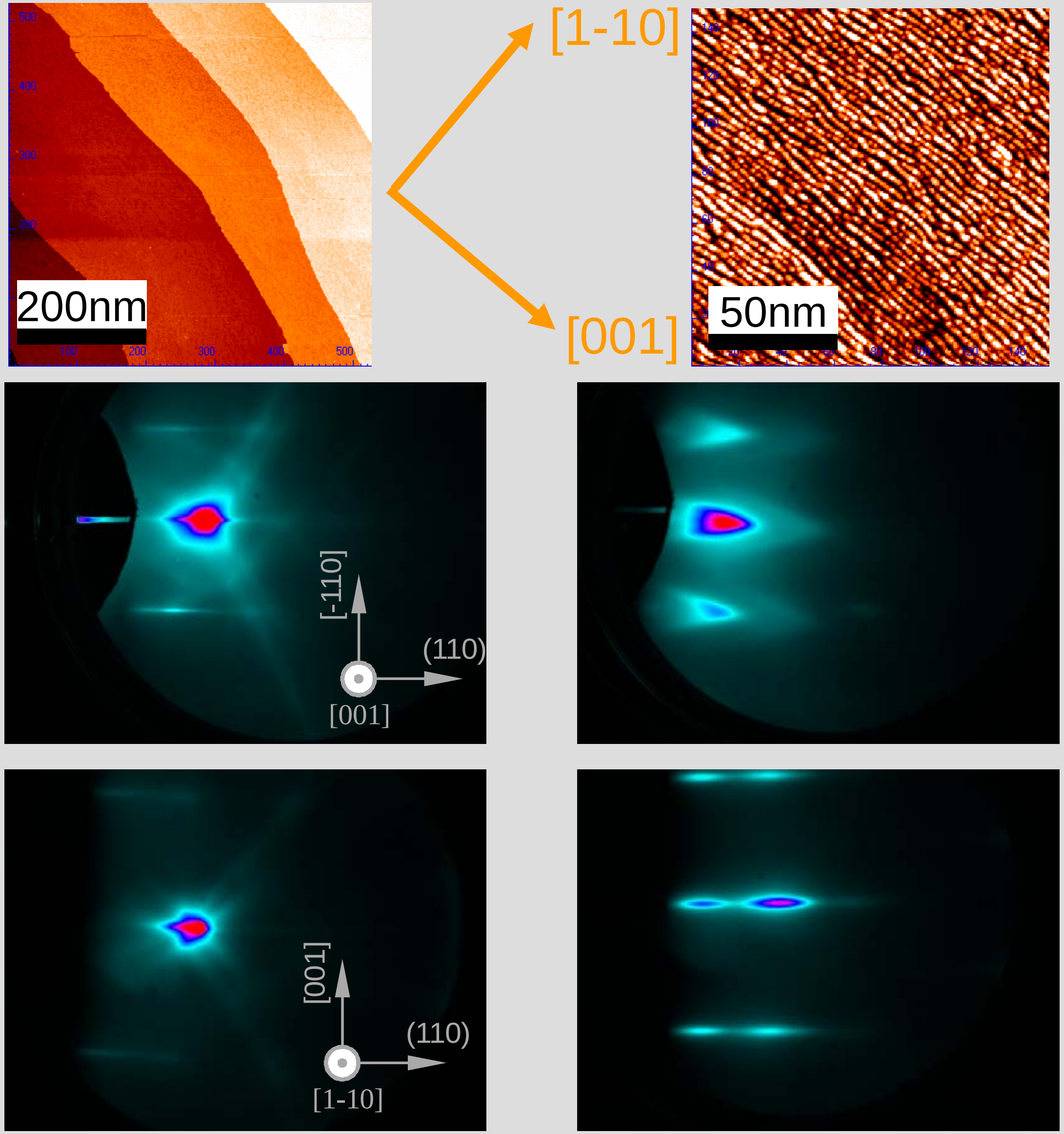


- Uniaxial array of trenches (epitaxial)
- Long-range orientational order

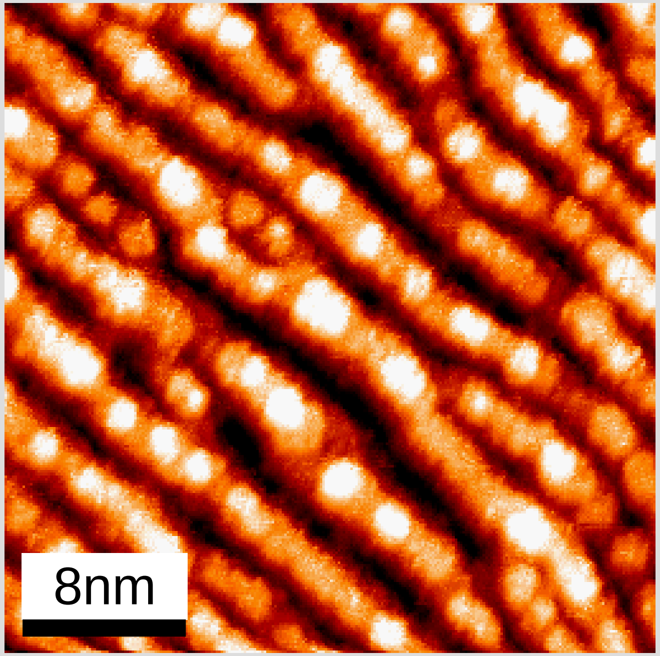
RHEED

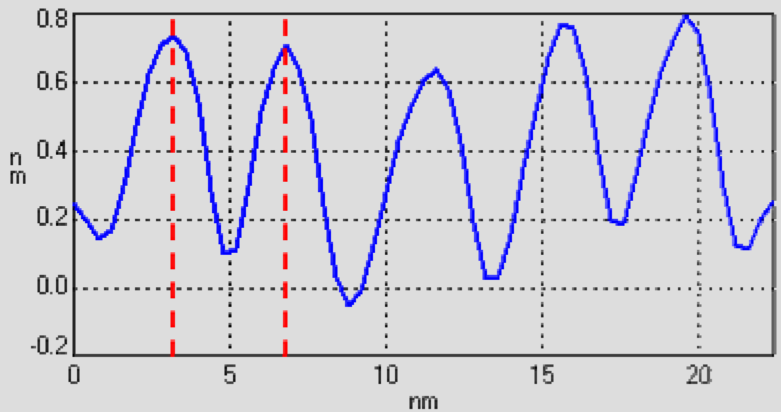
Mo, RT, annealed

Mo, RT

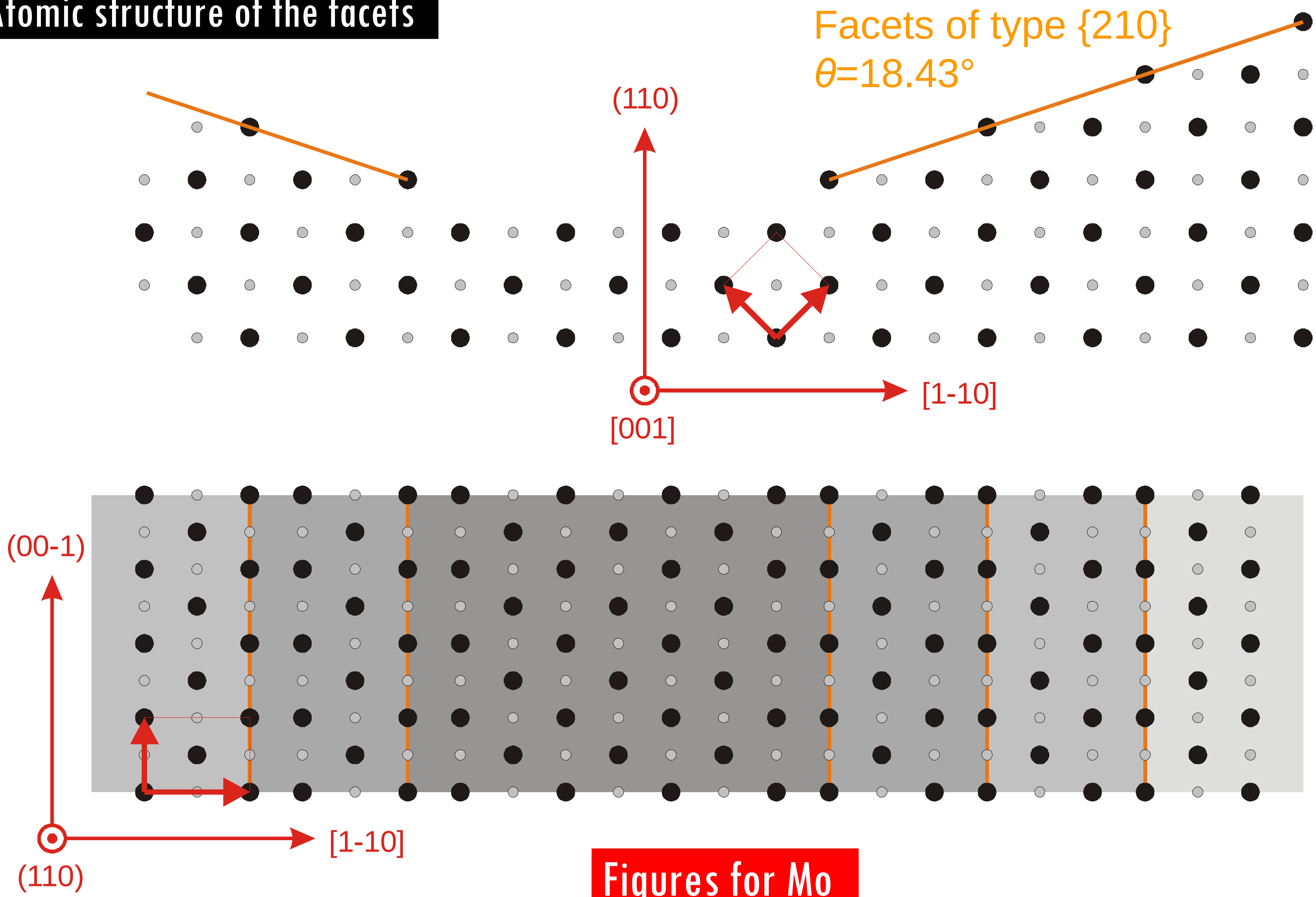


STM





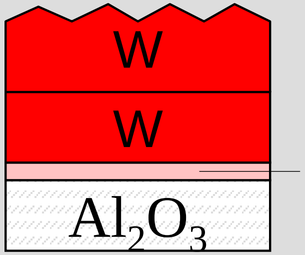
Atomic structure of the facets



Figures for Mo

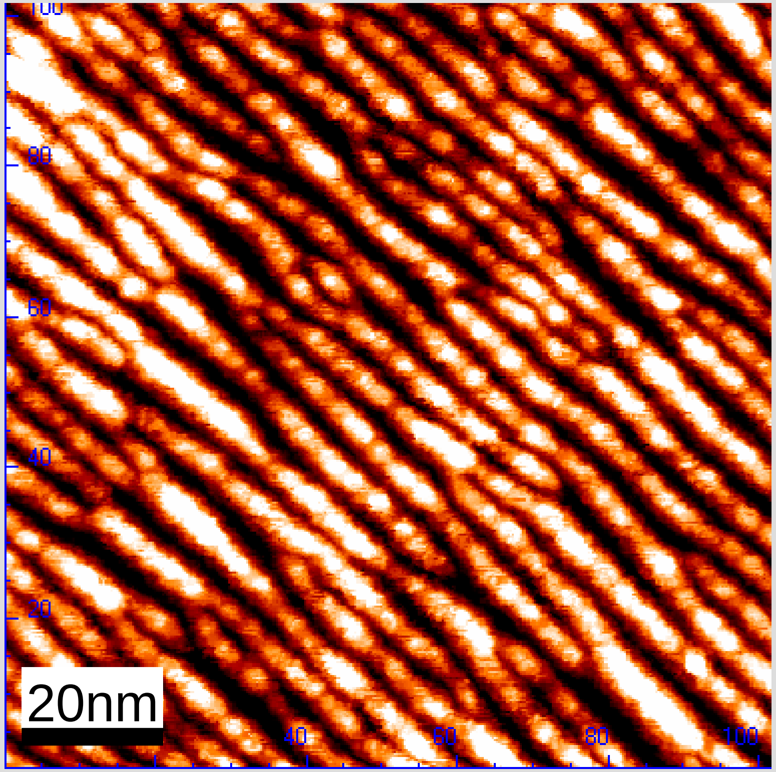
- Lateral period ~5 nm
- Depth of trenches: 0.6-1 nm

Process for W



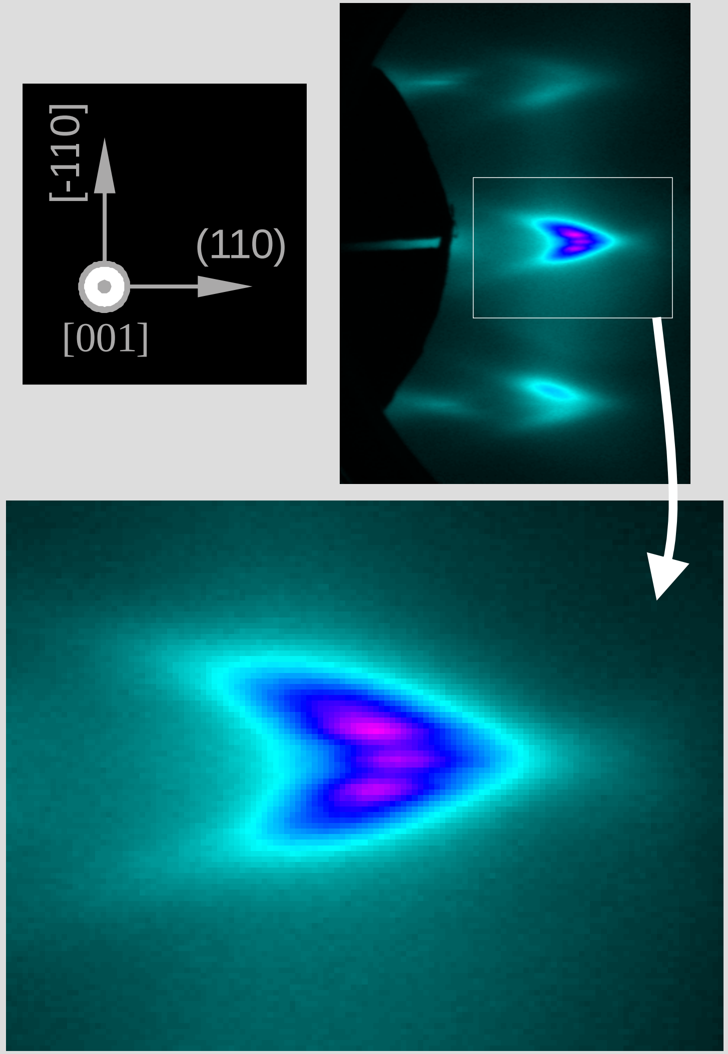
STM

W deposited at 150°C



Lateral period ~5.5 nm

RHEED



Satellite streaks

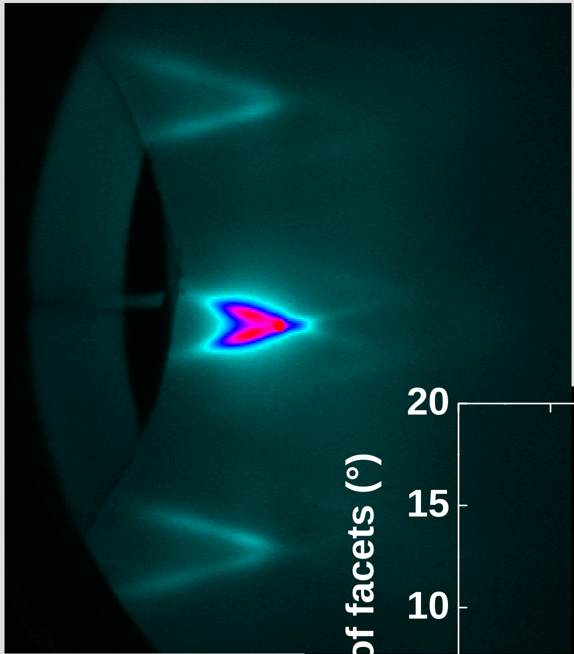
> Lateral period ~5.5 nm

Order is improved with W

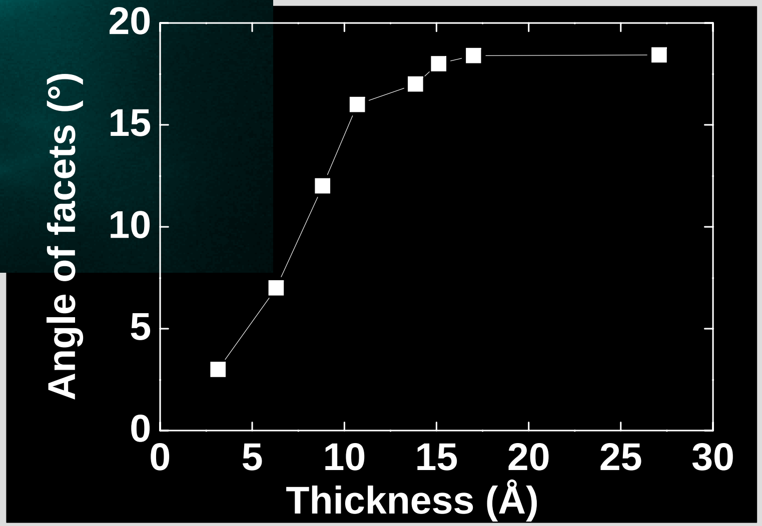
RHEED

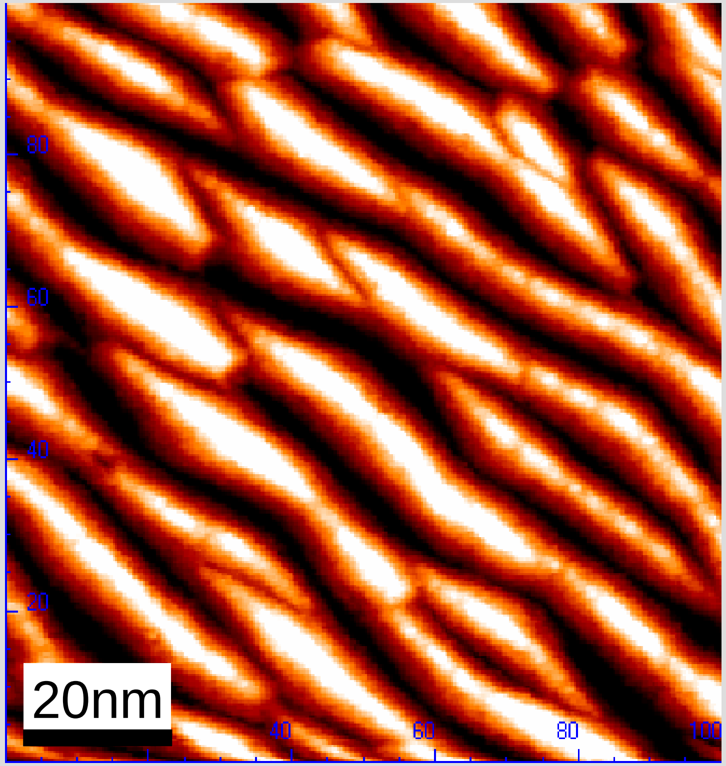
W deposited under decreasing temperature: 550°C ↘ 150°C

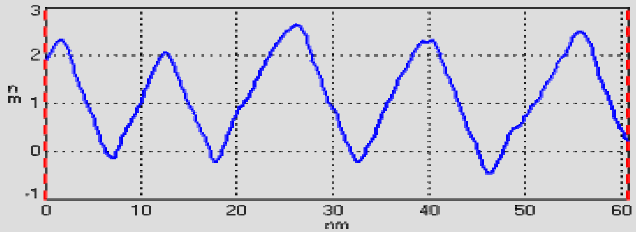
STM



>>> RHEED video



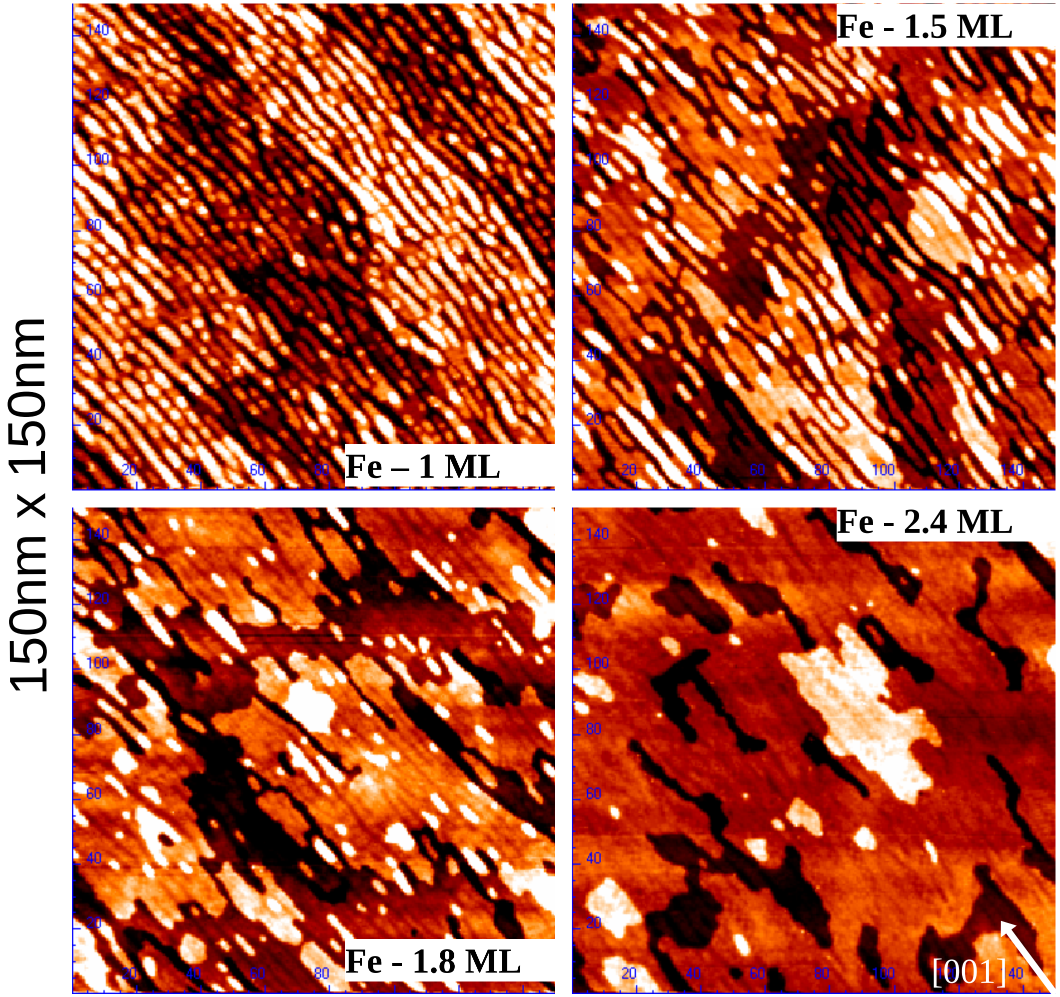


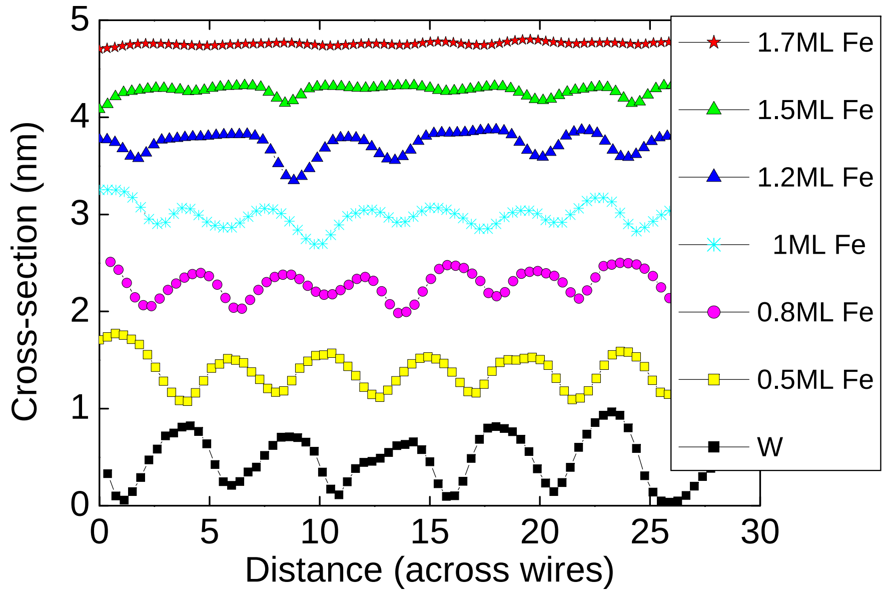


- Well-defined facets
- {210} is the limiting facet [contrary to statement of Köhler et al. On small trenches, {310} (2000)]

- Period ~ 10-12 nm
- Depth ~ 2-3 nm

Fe/W(110) with small period (5nm) at 150°C

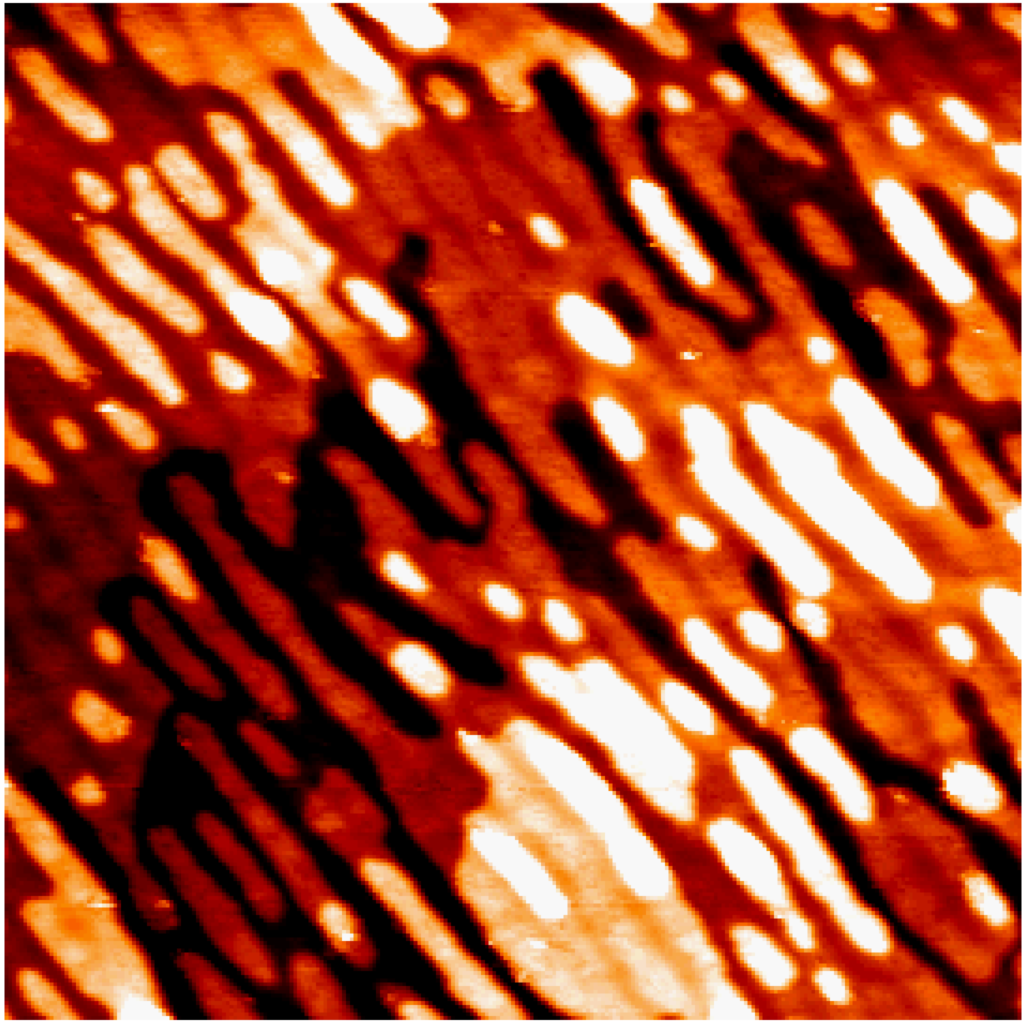




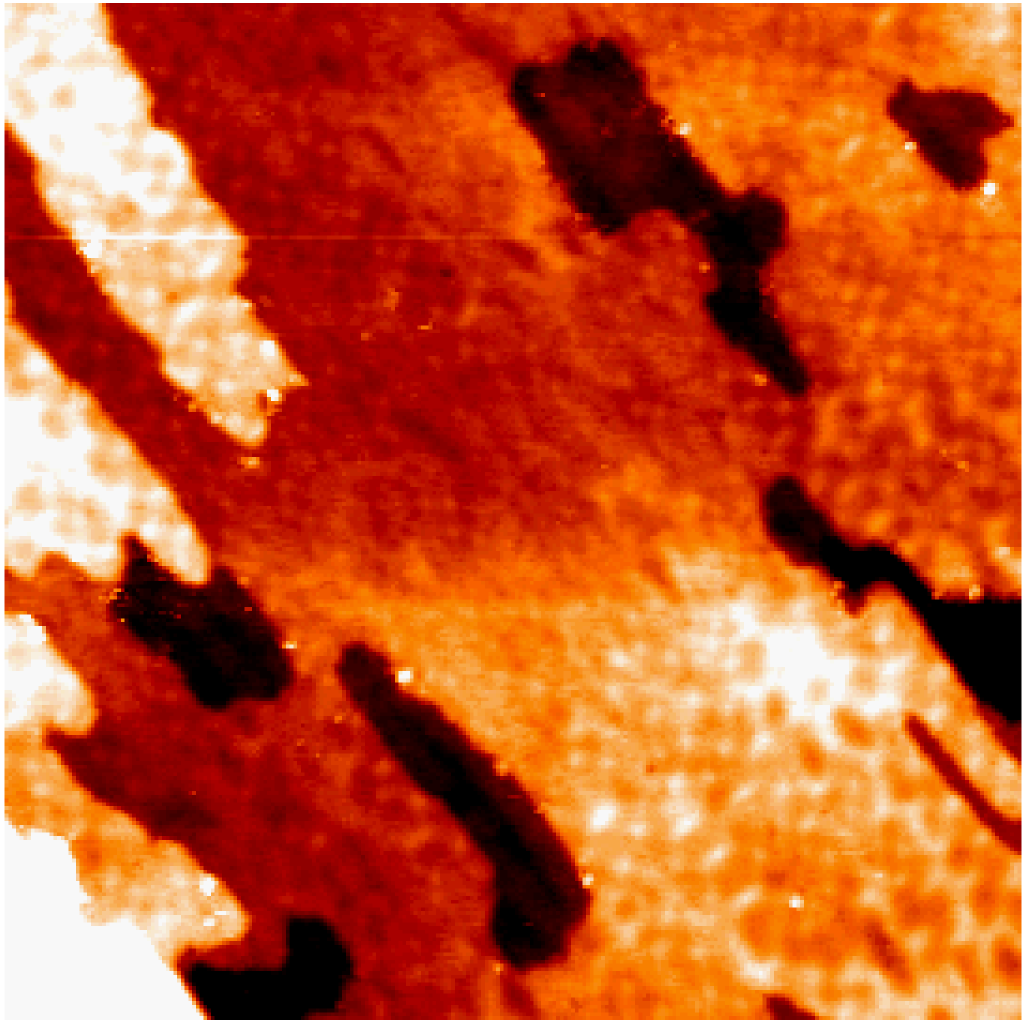
- Layer-by-layer growth
- Forms a smooth surface

Some details about continuous films

Residual corrugation across the trenches



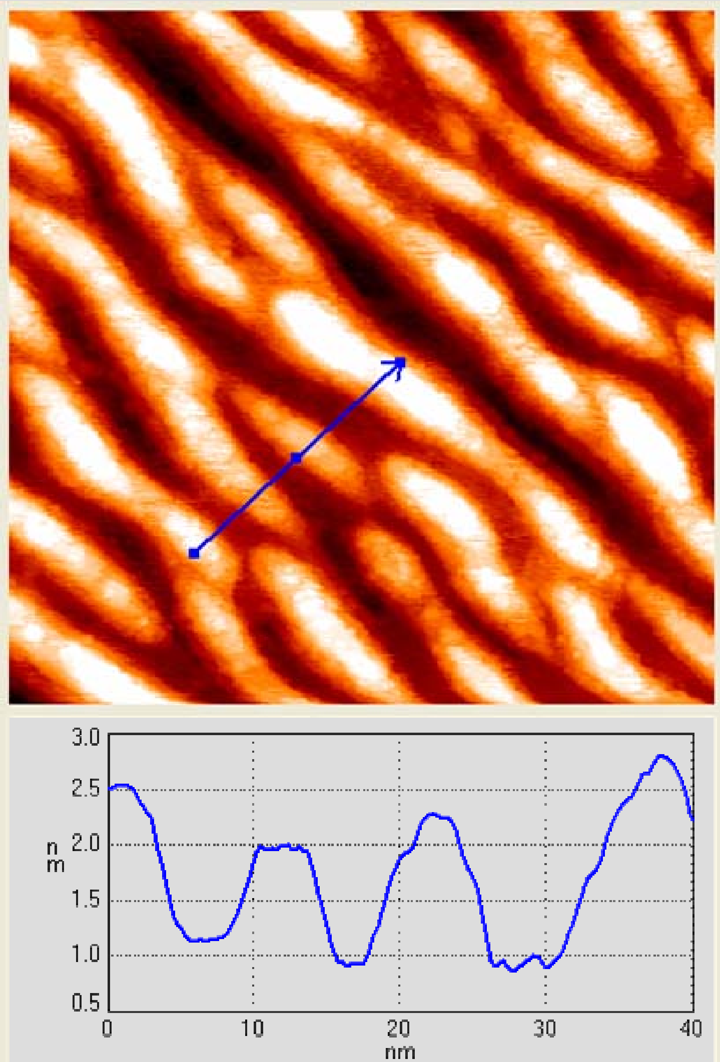
Zoology of misfit dislocations



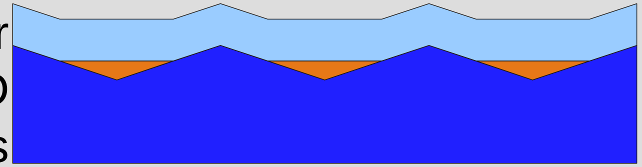
Structure

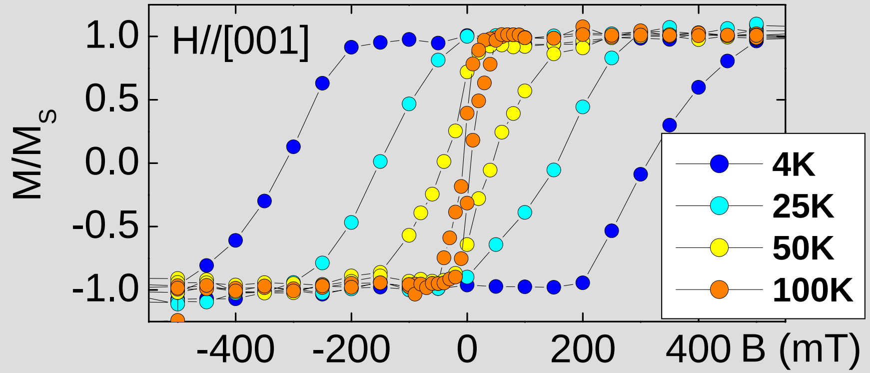
2.5ML Fe/W(110) with large period (12nm) at 150°C

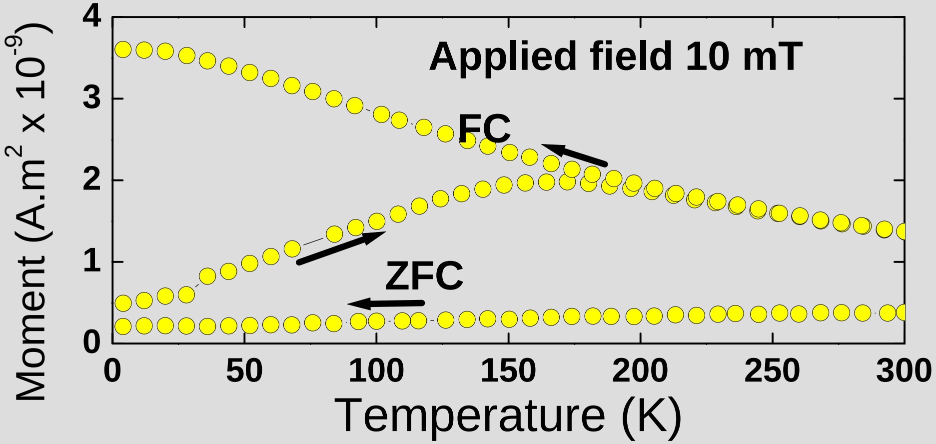
Magnetism



Capping for SQUID measurements





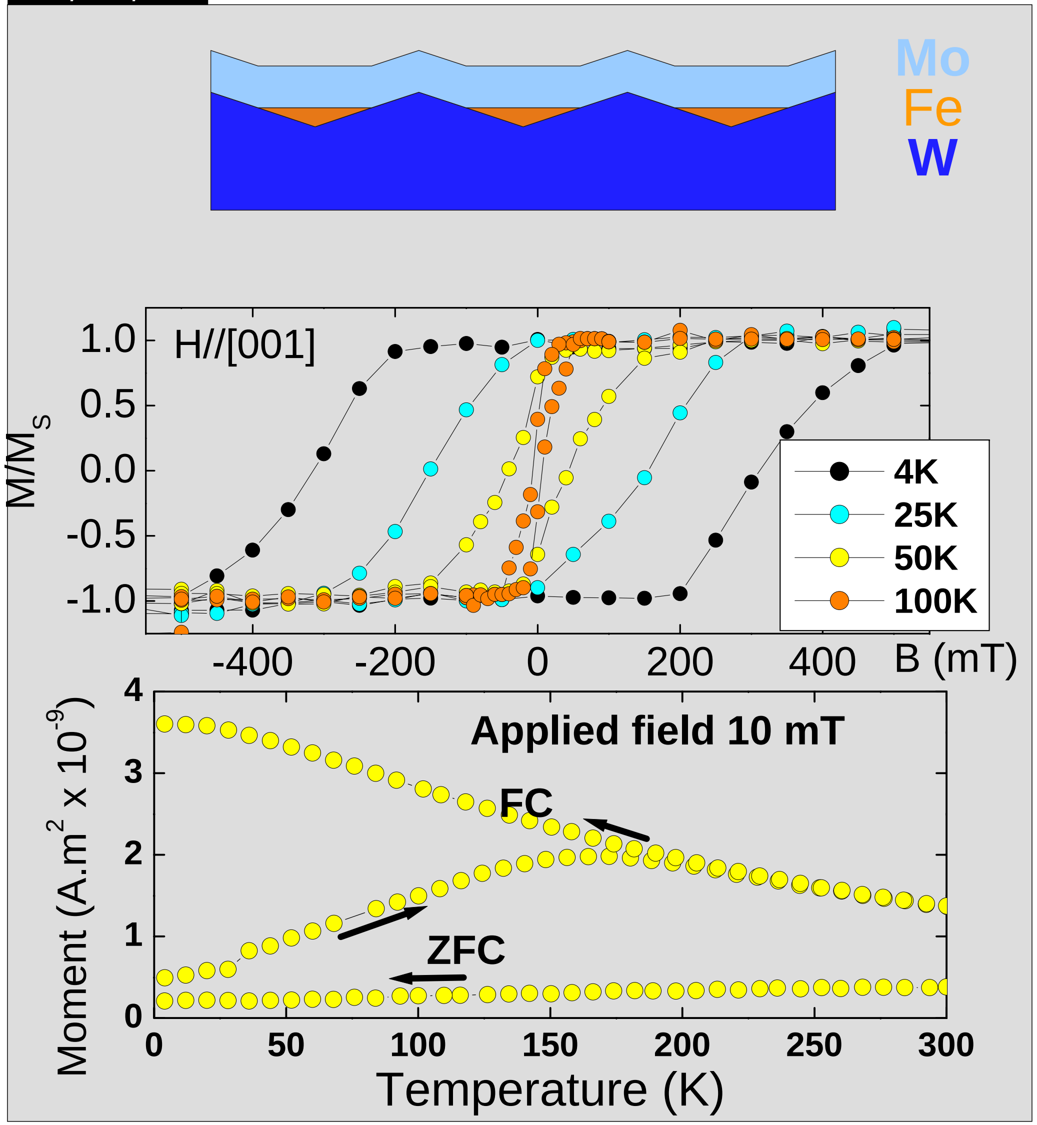


Fe stripes at the bottom of the trenches

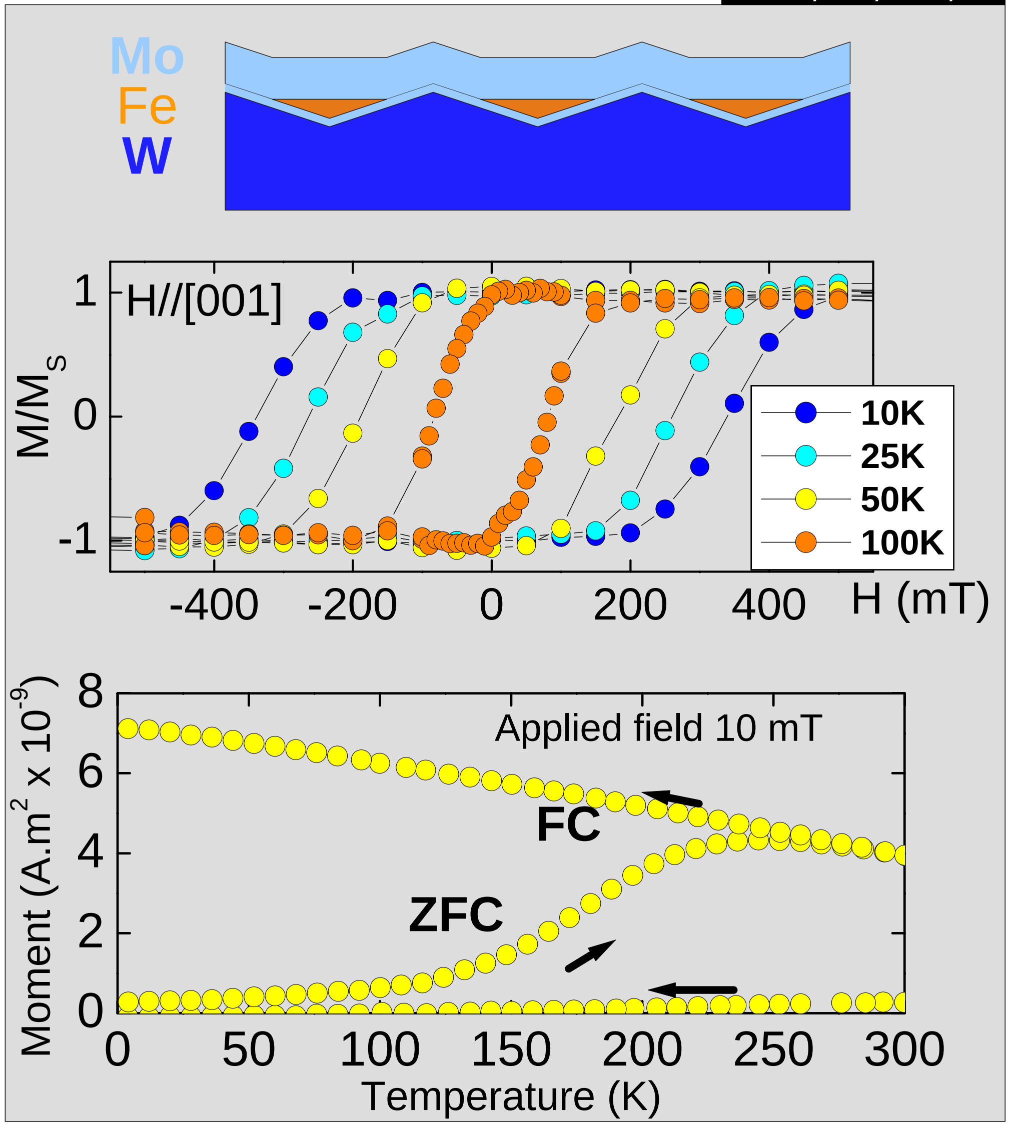
Easy axis along in-plane [001]

Mean blocking temperature 100K

Mo/Fe/W



Mo/Fe/Mo/W



- Fe/Mo surface anisotropy along [001] > Anisotropy increased
- Mean blocking temperature 175K

Engineer further magnetic anisotropy

By what means?

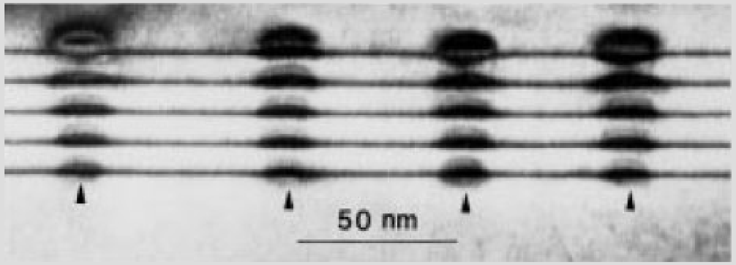
- Magnetic material
- Capping material
- Etc.

What for?

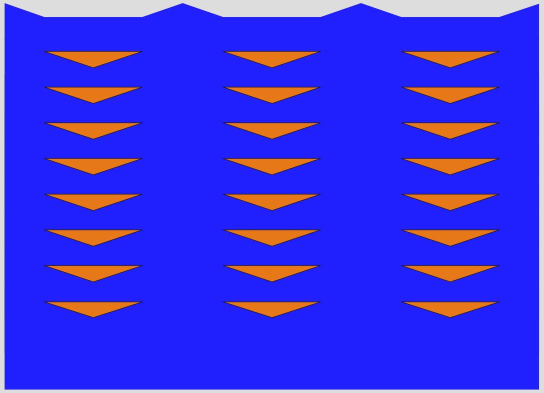
- Blocking temperature above 300K
- Get perpendicular anisotropy

Fabrication of multilayers

(Widespread for semiconductor QDs)



Q.Xie et al., PRL 75(13), 2542 (1995)



>>> RHEED Movie (Step: W)

What for?

- Unusual (not demonstrated?) for metals
- What becomes of strain, dislocations etc?
- Influence on magnetic anisotropy?
- Futuristic: trend of magnetic recording towards 3D (Cf S.S.P. Parkin, R. Cowburn)